Asian Journal of Basic Science & Research
Volume 7, Issue 1, Pages 83-88, January-March 2025

Estimation of Stature from Head Length using Regression Analysis in an Adult Population of West Bengal, India

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DOI: https://doi.org/10.38177/AJBSR.2025.7111

Article Received: 15 January 2025 *Article Accepted: 25 March 2025* *Article Published: 29 March 2025*

ABSTRACT

Background: Stature estimation in human identification has significant forensic importance. Measurements of various body parts such as head, arms, and leg can be used to estimate stature. This study was conducted to determine if there is a correlation between the stature and head length among the West Bengal population. **Objective:** The objective was to identify any correlation between head length and body height. **Methods:** Spreading caliper and standard height-measuring instrument were used for the analysis. The study included 112 adult males and 107 adult females of age 21–25 years. The two parameters (head length and body height) were measured and analysed. **Results:** The quantitative data collected from subjects were studied using statistical analysis. The quantitative data obtained from head length were found to have a significant positive correlation with stature. **Conclusion:** From the present research, we conclude that head length may be a moderately reliable parameter for stature estimation in both genders.

Keywords: Stature Estimation; Head Length; Regression Equation; Anthropometry; West Bengal Population; Adult; Nasion-Inion Length.

1. Introduction

Body height is a key measure of physical identity, demonstrating a dimensional relationship with various body parts [1]. This relationship aids in determining height from dismembered or mutilated body parts during forensic examinations. Anthropometric techniques, which are widely employed by anthropologists and medical scientists, have been used for years to estimate height. The estimation of an individual's height through measurements of different body parts has long intrigued anthropologists. Extensive research has focused on estimating height from measurements of various body parts, such as foot length, foot breadth, and superior extremity length [2,3]. Each researcher has proposed distinct formulas for calculating stature from long bone lengths, but the existing formulae vary due to variations in the relationship between stature and long bone length across race, age, sex, and body side (right or left) [4,5]. However, no widely accepted formula has been developed to estimate height from head length in the West Bengal population.

1.1. Study Objectives

The objectives of this study were:

1. To measure stature (body height) and head length in a sample of adult males and females aged 21-25 years from the Burdwan region of West Bengal.

2. To determine the mean values, standard deviations, and ranges for stature and head length in the male and female subjects studied.

3. To compare the mean stature and mean head length between male and female participants to identify significant sex differences.

4. To investigate the nature and strength of the correlation between head length and stature for males and females separately within this population group.

5. To derive specific linear regression equations for estimating stature based on head length for adult males and females of the studied population.

6. To assess the potential utility and reliability of using head length measurements for stature estimation in forensic applications pertinent to this population.

2. Materials and Methods

This study was conducted on 112 adult males and 107 adult females from the Burdwan region, all of similar socio-economic status. Subjects ranged in age from 21 to 25 years. Prior to participation, subjects were informed about the procedure, and informed consent was obtained. Participants with normal craniofacial structures and stature were included, while those with growth disorders, cranial bone deformities, or a history of craniofacial trauma or surgery were excluded. Head length was measured using a spreading caliper, and height was recorded with a standard height-measuring instrument.

3. Results

The findings of this study are summarized in Tables 1 and 2.

Table 1. Comparison of total height (in cm) of the subjects

Sex	Number	Height (mean)	Height (range)	S.D.
Male	112	173.5	153.2 - 190.8	+ 39.8
Female	107	157.9	145.6 - 171.7	+ 28.7

p value and statistical significance:

p value equals 0.0011. By conventional criteria, this difference is considered to be very statistically significant.

Confidence interval:

Difference of the mean height of male and female subjects is 15.6.

95% confidence interval of this difference: from 6.322 to 24.878.

t value = 3.3139, degree of freedom = 217, standard error of difference = 4.707;

Standard error of mean: for males 3.761, for females 2.775.

Table 2. Comparison of head length (in cm) of the subjects

Sex	Number	Head length (mean)	Head length (range)	S.D.
Male	112	18.2	16.5 - 20.6	+ 3.9
Female	107	17.3	15.3 - 19.1	+ 2.7

p value and statistical significance:

p value equals 0.0493. By conventional criteria, this difference is considered to be statistically significant.

Confidence interval:

Difference of the mean head length of male and female subjects is 0.900.

95% confidence interval of this difference: from 0.003 to 1.797.

t = 1.9769, degree of freedom = 217, standard error of difference = 0.455;

Standard error of mean: for males 0.369, for females 0.261.

4. Discussion

Stature estimation is a critical aspect of identifying unknown or commingled human remains [6,7]. Dimensional relationships between body segments and the whole body have interested artists, scientists, anatomists, anthropologists, and forensic experts for a long time. Various factors, including genetics, nutrition, geographic location, physical activity, and race, influence anthropometric data [8,9]. This study focused on individuals aged 21 to 25 years, as long bones are fully ossified by this age.

Table 1 reveals that there is a very statistically significant difference in the mean heights of male and female subjects. Table 2 reveals that there is a statistically significant difference in the mean head lengths of male and female subjects.

Previous studies have shown a strong correlation between height and foot length or foot breadth [10,11]. Some researchers have found correlation coefficients of 0.20 (Saxena et al., 1981), 0.53 (Jadav & Shah) and 0.78 (Krishan, 2008) between cranial length and height [12,13,14]. Chiba & Terazawa derived a regression equation for height from head length in Japanese cadavers [15]. Few studies have reported a statistically insignificant correlation between stature and skull parameters [16,17]. The correlation coefficient of stature for skull parameters (head length, head breadth and head circumference) was found to be nonsignificant in other studies [18]. However, few data exist in the literature regarding stature estimation from head length, although Glaister suggested that the Nasion-inion length is approximately 1/8th of an individual's total height [19]. In the present study we found a significant correlation between head length (Nasion-inion length) and total height. The regression equations derived from this study to estimate total height from head length are as follows:

- **For males:** $Y = 138.77 + 1.77X$
- **For females:** $Y = 128.03 + 1.72X$

Here, Y represents total height and X denotes head length. These equations demonstrate that if either head length or total height is known, the other can be calculated. This knowledge has practical applications in medicolegal investigations and anthropology.

5. Limitations of the Study

Further studies with larger samples, including individuals over 25 years of age, from various Indian ethnic groups, are recommended to enhance the results. It should also be noted that anthropometric measurements obtained from living individuals may differ in their applicability to deceased individuals.

6. Conclusion

Based on the findings of the present research, we conclude that head length can be considered a moderately reliable anthropometric parameter for estimating an individual's stature in both males and females. This suggests that head length may be useful in forensic investigations and other scientific applications where accurate height estimation is required. However, while it shows potential as a predictive measure, further research with larger samples, from various ethnic groups should be conducted to obtain more precise and reliable results.

7. Future Recommendations

To further enhance the applicability and precision of stature estimation from craniofacial parameters in this region, the following future studies are recommended:

1. **Expand Sample Size and Demographics:** Conduct similar studies with significantly larger sample sizes covering a wider age range (including individuals older than 25 years) and diverse socio-economic backgrounds within West Bengal to improve the statistical robustness and generalizability of the findings.

2. **Cross-Population Validation:** Extend the research to include different ethnic and geographical groups across Eastern India and compare the results to understand population-specific variations and potentially develop broader regional formulae.

3. **Incorporate Additional Measurements:** Investigate the correlation of stature with other cephalofacial measurements (e.g., head breadth, facial height, bizygomatic breadth) alongside head length to potentially develop multivariate regression models that may offer higher predictive accuracy.

4. **Validation on Independent Samples:** Test the accuracy and reliability of the currently derived regression equations on a new, independent sample drawn from the same target population (adults aged 21-25 from the Burdwan region) to validate their practical utility.

Declarations

Source of Funding

This study did not receive any grant from funding agencies in the public or not-for-profit sectors.

Competing Interests Statement

The author declares that he has no conflict of interest.

Consent for publication

The author declares that he consented to the publication of this study.

Authors' contributions

Author’s independent contribution.

Ethical approval and consent to participate

Not applicable for this study.

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